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FINAL REPORT

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Methodologies to Determine Forces on Bones and Muscles of Body Segments During Exercise, Employing Compact Sensors Suitable for Use in Crowded Space Vehicles

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(NASA-CR-197943) METHODOLOGIES TO DETERMINE FORCES ON BONES AND MUSCLES OF BODY SEGMENTS DURING EXERCISE, EMPLOYING COMPACT SENSORS SUITABLE FOR USE IN CROWDED SPACE VEHICLES Final Report, Oct. 1993 - Sep. 1994 (Tulane Univ.) 3 p

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SUMMARY OF THE PROJECT

Work under this grant was carried out by the PI and by a graduate research assistant. An instrumented bicycle ergometer was implemented focusing on the stated objective: to estimate the forces exerted by each muscle of the feet, calf, and thigh of an individual while bicycling. The sensors used were light and compact. These were probes to measure muscle EMG activity, miniature accelerometers, miniature load sensors, and small encoders to measure angular positions of the pedal. A methodology was developed and implemented to completely describe the kinematics of the limbs using data from the sensors. This work has been published as a Master's Thesis by the Graduate student supported by the grant, Liu (1994). The officially required number of copies of the thesis are included with this report. The instrumented ergometer along with the sensors and instrumentation were tested during a KC-135 Zero-Gravity flight in July, 1994. A complete description of the system and the tests performed have been published as a report submitted to NASA Johnson Space Center by the PI, Figueroa (1994). The data collected during the KC-135 flight is currently being processed so that a kinematic description of the bicycling experiment will be soon determined. A methodology to estimate the muscle forces has been formulated based on similar work done by Redfield and Hull (1986), Davy and Audu (1987), Herzog and Leonard (1991), Chou et. al. (1993), and Harrison et. al. (1986). The methodology involves the use of optimization concepts so that the individual muscle forces that represent variables in the dynamic equations of motion may be estimated. Optimization of a criteria (goal) function such as minimization of energy will be used along with constraint equations defined by rigid body equations of motion. Use of optimization principles is necessary, because the equations of motion alone constitute an indeterminate system of equations with respect to the large amount of muscle forces which constitute the variables in these equations. The number of variables is reduced somewhat by using forces measured by the load cells installed on the pedal. These load cells measure pressure and shear forces on the foot. The PI and his collaborators at NASA and at the University of Alabama, Tuscaloosa, are continuing the work of reducing the experimental data from the KC-135 flight, and the implementation of the optimization methods to estimate muscle forces. As soon as results from these efforts are available, they will be published in reputable journals.

Results of this work will impact studies addressing bone density loss and development of countermeasures to minimize bone loss in zero gravity conditions. By analyzing muscle forces on Earth and in Space during exercise, scientists could eventually formulate new exercises and machines to help maintain bone density. On Earth, this work will impact studies concerning arthritis, and will provide the means to study possible exercise countermeasures to minimize arthritis problems.

ENCLOSURES

Copies of a Master's Thesis supported by this grant.
Copies of a previous Status Report.

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